COST-BENEFIT ANALYSIS GUIDE FOR NIH IT PROJECTS

Prepared by

Robert Lagas
301-402-4464
lagasr@nih.gov

THE OFFICE OF INFORMATION RESOURCES MANAGEMENT

CENTER FOR INFORMATION TECHNOLOGY

NATIONAL INSTITUTES OF HEALTH

October, 1998

Table of Contents

1 INTRODUCTION

The current laws relating to managing Information Technology (IT) in the Federal government **require** a Cost-Benefit Analysis[1] (CBA) prior to implementing an IT project. Cost-Benefit Analysis can be as simple as deciding to buy a new keyboard for your computer when the keyboard stops working after a drink is spilled on it. The process described in this guide would be appropriate for a project as large and complex as modernizing the Internal Revenue Service tax systems. A Cost-Benefit Analysis should be commensurate with the size, complexity and cost of the proposed project, and project managers have to decide what level of analysis is necessary for a specific project in their IT management environment.

1.1 PURPOSE OF THIS GUIDE

This document provides guidance for preparing a CBA for an IT project in the National Institutes of Health (NIH). It was developed to assist technical and administrative personnel in preparing CBAs, it can also be used by managers to determine if a CBA appropriately supports decisions to invest funds in an IT project. Some parts of this guide could also be used to perform an A-76 study.

1.2 STRUCTURE OF THIS GUIDE

- **Section 2** addresses the general concepts of cost-benefit analysis.
- **Section 3** contains an overview of the entire process.
- **Section 4** provides a detailed description of the individual steps.
- **Appendices** contain a glossary of terms, detailed descriptions of cost categories, lease-purchase guidance, and discount factors.

1.3 OMB GUIDANCE

General guidance for CBAs has been issued by the Office of Management and Budget (OMB) and is available on the web[2].

- **OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis[3] of Federal Programs**, is a general guide that does not specifically address IT projects. Its URL is http://www.whitehouse.gov/WH/EOP/OMB/html/circulars/a094/a094.html. The current version of A-94 was issued in October 1992 and replaced the March 1972 version.

- **OMB Circular A-76, Performance of Commercial Activities**, provides guidance for developing cost estimates for government and contractor performance of activities. Its URL is

[1] See Appendix A, Glossary of Terms, for a formal definition.

[2] Clicking on the URL will hotlink to those documents in an HTML version of this guide.

[3] The term Cost-Benefit Analysis is often used interchangeably with the term Benefit-Cost Analysis. Cost-Benefit Analysis is used as the title and the primary term in this document.

http://www.whitehouse.gov/WH/EOP/OMB/html/circulars/a076/a076s2t.html.

1.4 ACKNOWLEDGMENTS

This guidance is based primarily on OMB Circular A-94 with specific recommendations for the preparation of Cost-Benefit Analyses to justify the continuation or initiation of IT projects. It also utilizes material and concepts from the following sources:

- OMB Circular A-76, Performance of Commercial Activities
- Federal Aviation Administration Study, Baseline Cost Element Matrix
- NASA Outsourcing Guide and Benefit-Cost Model
- NIH IT Management Guide (http://irm.cit.nih.gov/itmra/itmgmtgd.html)
- OMB Circular A-11, Preparation and Submission of Budget Estimates (old version)

2 GENERAL CONCEPTS OF COST-BENEFIT ANALYSIS

The general concepts of Cost-Benefit Analysis (taken primarily from OMB Circular A-94) are addressed below.

2.1 PURPOSE

The purpose of a CBA is to support better decision-making to ensure that resources are effectively allocated to support the NIH mission. The CBA should demonstrate that at least three alternatives were considered, and the chosen alternative is the most cost-effective within the context of budgetary and political considerations.

2.2 TIME PERIOD

The CBA time period should match the system life cycle. The system life cycle includes the following stages/phases:

- feasibility study
- design
- development
- implementation
- operation
- maintenance

A system life cycle ends when the system is terminated or is replaced by a system that has significant differences in processing, operational capabilities, resource requirements, or system outputs. Significant differences is a very subject term, and some organizations may feel that a 10% change is

significant, while others may that the change must be over 30% to be significant.

2.3 ALTERNATIVES

Analyses must consider at least three alternative means of achieving program objectives, one of which is to continue with no change. This provides a comparative baseline. Other alternatives could include:

- in-house development versus contractor development
- in-house operation versus contractor operation
- leasing equipment versus purchasing equipment
- current operational procedures versus new operational procedures
- One technical approach versus another technical approach

2.4 TWO TYPES OF ANALYSIS

Benefit-Cost Analysis (BCA) is a systematic, quantitative method of assessing the life cycle costs and benefits of competing alternative approaches. This includes determining which one of the alternatives is best.

A **Cost-Effectiveness Analysis** is a simplified BCA, which can be done when either the benefits or the costs are the same for all alternatives. In that situation, the analysis is greatly simplified because the best alternative is either the one with the most benefits (when the costs are the same for all alternatives) or the one with the lowest cost (when the benefits are the same for all alternatives).

2.5 IDENTIFYING AND MEASURING BENEFITS AND COSTS

CBAs must include comprehensive estimates of the projected benefits and costs for all alternatives. Benefits to which a dollar value cannot be assigned (intangible benefits) should be included along with tangible benefits and costs. Intangible benefits should be evaluated and assigned relative numeric values for comparison purposes. For example, maximum benefit could be assigned a value of 5, average benefits a value of 3, and minimum benefits a value of 1. Evaluating and comparing benefits that have both dollar values and relative numeric values requires extra effort, but it allows subjective judgment to be a factor in the analysis.

CBAs should be explicit about the underlying assumptions used to arrive at estimates of future benefits and costs. For example, the number of users of an IT system might be assumed to increase at a rate of 10% each of the 6 years of the system life cycle.

Costs incurred in the past (Sunk Costs) and savings or efficiencies already achieved (Realized Benefits) should not be considered in a CBA. When a CBA is done on a project that is already underway, there may be pressure to compare all costs and benefits from the beginning of the project. In that situation, the question to be answered is whether or the benefits of proceeding justify the costs associated with continuing the project. The classic example of this is a situation where large amounts

of money have been spent designing a system that has not been successfully implemented, and the project is being re-evaluated. The fact that a lot of money has been spent is no reason to continue spending. CBAs focus on the future; and decisions have to be based on the expected costs and benefits of the proposed alternatives. Past experience is relevant only in helping estimate the value of future benefits and costs.

2.6 DECISION CRITERIA

Project should be initiated or continued only if the projected benefits exceed the projected costs. The only exception is if benefits are mandated by law.

Benefit-Cost Analysis - The standard criterion for justifying an IT project is that the benefits exceed the costs over the life cycle of the project. The competing alternative with the greatest net benefit (benefits minus costs) should be selected. When all benefits and costs cannot be assigned monetary values, relative values for costs and benefits can be used, and the alternative with the greatest net benefit (benefit values minus cost values) should still be selected.

Cost-Effectiveness Analysis - When comparing alternatives with identical costs and different benefits, the alternative with the largest benefits should be selected. When comparing alternatives with identical benefits and different costs, the alternative with the lowest costs should be selected.

3 OVERVIEW OF THE CBA PROCESS

3.1 WHEN IS A CBA REQUIRED?

A CBA is always required before a decision is made to initiate or continue an IT project; the only issue is the level of detail required for the analysis. The process described here is appropriate for a very large, complex, and costly IT project. Scaled down versions of the CBA would be appropriate for smaller, less costly projects; and your organization should provide guidelines to determine the amount of scaling that would be appropriate for IT projects based on their size, cost, and complexity.

3.2 WHEN IS THE CBA PERFORMED?

A cost-benefit analysis should occur prior to initiating or modifying an IT system. Most of the activities described below are part of the IT management process at NIH[4], and may be completed before the CBA is initiated, concurrently with the CBA, or as part of the CBA. The CBA is a key input for the investment review that should take place before a new project proceeds to the acquisition or development phase.

[4] More information about the IT management process at NIH can be found in the **NIH IT Management Guide**.

- **DEFINE THE PROBLEM** - Clearly define and document the problem. If possible, it should be described from a management perspective.

- **REVIEW THE CURRENT WORK PROCESS DOCUMENTATION** - If no documentation exists, it must be developed. If it is not clear and up-to-date, it should be updated to clearly describe the current work process. The information processing requirements must be part of the documentation for the current work process or the current IT system.

- **EVALUATE THE WORK PROCESS** - There are two questions to address in the work process evaluation: Should We Be Doing This? and Can the Process Be Improved?

- **DEFINE THE NEW PROCESSING REQUIREMENTS** - Define the information processing requirements for the proposed work process at a general level. The security requirements should be addressed in terms of data integrity, reliable processing, privacy and confidentiality.

- **DETERMINE IT PERFORMANCE MEASURES** - Identify indicators for measuring and assessing performance of the process and the IT system in relation to the NIH mission. Also determine the means of collecting and storing the performance data.

3.3 WHO SHOULD DO THE CBA?

One person should be responsible for performing a CBA. However, because one person rarely has expertise in all of the areas required for a CBA, that person will need to assemble a team with expertise in IT systems development and operation, budget, finance, statistics, procurement, IT architecture and the work process being analyzed. More importantly, a team brings different perspectives to the analysis and the process of estimating costs and benefits, and should ensure more realistic estimates than those of just one person.

3.4 HOW IS THE CBA PERFORMED?

This section briefly describes the steps required to perform a CBA for a large IT project.

3.4.1 Determine/Define Objectives

The CBA should include the project objectives and other pertinent background information so that it stands on its own and can be understood by a reviewer who is not intimately familiar with the organization and its work process. The objectives should be designed to improve the work process so NIH can better perform its mission. If this information is available from previous steps of the IT management process, it should either be incorporated directly into the CBA or fully referenced in the CBA.

3.4.2 Document Current Process

The baseline for any CBA is the current process. Because understanding the current process

provides the basis for decisions regarding new alternatives, a CBA must thoroughly document the current process to ensure that everyone involved in the CBA preparation and review understands that process. The primary areas to be documented are Customer Services, System Capabilities, Technical Architecture, and System Costs.

3.4.3 Estimate Future Requirements

Future customer requirements determine the system capabilities and architecture, and ultimately affect system costs and benefits. Thus, it is very important to accurately estimate the future requirements. The two key items to consider are the system life cycle and the peak life cycle demands. A number of useful forecasting methods are discussed in Section 4.

3.4.4 Collect Cost Data

Cost data must be collected for estimating the cost and benefits of each project alternative. Six sources of data are historical organization experience, current system costs, market research, publications, analyst judgment, and special studies. This step is the preparation for the actually estimating costs and benefits in later steps.

3.4.5 Choose At Least Three Alternatives

A CBA must present at least three alternatives. One alternative that should be always be included in the CBA is to continue with no change. During the Work Process Evaluation, a number of alternatives may be considered. Other alternatives are whether to do development, operations, and maintenance with in-house personnel or contractors. Each technical approach that is a viable alternative from a work process perspective should be included as an alternative. However, the number of technical approaches may be limited if only one or two are compatible with the NIH IT architecture. Some alternatives can be addressed and rejected because they are not feasible for reasons other than costs and benefits.

3.4.6 Document CBA Assumptions

Because a CBA often relies on many assumptions, it is important to document all of them, and, if possible, justify them on the basis of prior experiences or actual data. For example, you may assume that the PC hardware and software for a system will need to be upgraded every three years. This could be justified on the basis of the rapid increases in capacity and speed and decreases in cost for PCs over the past 15 years.

This can also be an opportunity to explain why some alternatives were not included in the analysis. Some alternatives are eliminated in the early stages of a CBA because of a conclusion that it is not feasible. If that conclusion is based on an assumption, the assumption must be clearly explained and justified.

3.4.7 Estimate Costs

Many factors must be considered during the process of estimating the costs associated with competing alternatives in a CBA. All costs for the full system life cycle for each competing alternative must be included. The following factors must be addressed: Activities and Resources, Cost Categories, Personnel Costs, Direct and Indirect Costs (Overhead), Depreciation, and Annual Costs.

3.4.8 Estimate Benefits

Benefits are the services, capabilities, and qualities of each alternative system, and can be viewed as the return on investment (ROI). To estimate benefits, first identify the benefits for both the customers and the organization that provides the service(s) to the customers. Benefits to customers are improvements to the current IT services and/or the addition of new services. Some possible benefits for the servicing organization are productivity gains, staffing reductions, or improved organizational effectiveness.

After the benefits are identified, establish performance measures for each benefit. The final step is to estimate the value of the benefits. If a benefit cannot reasonably be assigned a monetary value, it should be valued using a more subjective, qualitative rating system (which assigns relative numerical values for the competing alternatives). All benefits for the full system life cycle for each competing alternative must be included.

3.4.9 Discount Costs and Benefits

After the costs and benefits for each year of the system life cycle have been estimated, convert them to a common unit of measurement to properly compare competing alternatives. That is accomplished by discounting future dollar values, which transforms future benefits and costs to their "present value." The present value (also referred to as the discounted value) of a future amount is calculated with the following formula:

$P = F\ (1/(1+I)^n)$, where P = Present Value, F = Future Value, I = Interest Rate, and n = number of years. Section 4 provides an example that shows how the costs and benefits are discounted.

3.4.10 Evaluate Alternatives

` When the costs and benefits for each competing alternative have been discounted, compare and rank the discounted net value (discounted benefit minus discounted cost) of the competing alternatives. When the alternative with the lowest discounted cost provides the highest discounted benefits, it is clearly the best alternative. Most cases not be that simple, and other techniques must be used to determine the best alternative. Section 4 describes and provides an example for several different techniques.

When some benefits have dollar values assigned, but others do not, the non-cost values can be

used as tie-breakers if the cost figures do not show a clear winner among the competing alternatives, and if the non-costed benefits are not key factors. If the non-costed benefits are key factors, the costed benefits can be converted to scaled numeric values consistent with the other non-costed benefits. The evaluation can then be done by comparing the discounted costs and the relative values of the benefits for each alternative. When the alternative with the lowest discounted cost provides the highest relative benefits, it is clearly the best alternative (the same basic rule used when you have discounted benefits). If that is not the case, the evaluation is more complex. Those techniques are addressed in Section 4.

If no benefits have dollar values, numerical values can be assigned (using some relative scale) to each benefit for each competing alternative. The evaluation and ranking is then completed in the manner described in the previous paragraph.

3.4.11 Perform Sensitivity Analysis

Sensitivity analysis tests the sensitivity and reliability of the results obtained from the cost-benefit analysis. Since the CBA is normally the key document in the investment review process, reviewers want assurance that the analysis is reliable. Sensitivity analysis identifies those input parameters that have the greatest influence on the outcome, repeats the analysis with different input parameter values, and evaluates the results to determine which, if any, input parameters are sensitive. If a relatively small change in the value of an input parameter changes the alternative selected, then the analysis is considered to be sensitive to that parameter. If the value of a parameter has to be doubled before there is a change in the selected alternative, the analysis is not considered to be sensitive to that parameter. The estimates for sensitive input parameters should be re-examined to ensure that they are as accurate as possible.

4 THE COST-BENEFIT ANALYSIS PROCESS

The Cost-Benefit Analysis process can be broken down into eleven different steps. Many of the steps and examples were taken from the National Aeronautics and Space Administration (NASA) Outsourcing Guide and Benefit-Cost Model[5]. The NASA model and the OMB Circular A-94 guidance served as the primary guides for this document. The examples provided here come from a variety of sources, and do not relate to one specific project. A sample CBA that includes examples for one project will be developed at a later date.

4.1 STEP 1 - DETERMINE/DEFINE PROJECT OBJECTIVES

The CBA should include the project objectives and other pertinent background information so that it stands on its own and can be understood by a reviewer who is not intimately familiar with the organization and its work process. The objectives should be designed to improve the work process so NIH can better perform its mission. This information should be available from previous steps of the NIH IT management process, and should either be incorporated directly into the CBA or fully

[5]NIH was unable to obtain an electronic copy of the NASA document.

referenced in the CBA. The key items to be addressed are:

- Problem Definition - The problem perceived by management must be clearly defined.
- Background - Pertinent issues such as staffing, system history, customer satisfaction should be addressed.
- Project Objectives - The objectives should be stated in terms of supporting the NIH mission.

Although it is important for the reader to understand the project objectives, the crucial issue is that the project manager and management understand what it is that they are trying to accomplish.

In some environments, a CBA may be initiated when management has only generally defined the problem. When that occurs, the time and effort required to complete the CBA will be increased significantly.

4.2 STEP 2 - DOCUMENT CURRENT PROCESS

Everyone involved in the preparation and review of the CBA needs to understand the current process because it is the baseline for nearly all decisions regarding new alternatives. Therefore the current process must be thoroughly documented. The areas to be addressed are Customer Services, System Capabilities, Technical Architecture, and System Costs. The current documentation should be revised if it does not address these areas, or does not reflect the current environment. If no documentation is available, it will have to be created.

4.2.1 Customer Services

Because every process or IT system provides services to customers, each customer's relationship with the processing organization should be clearly documented. This requires documenting the role and placement of the customer in their parent organization and specifically identifying the services provided. For example, one customer may be from the accounting area, and the processing organization may perform data entry, maintain an on-line database, execute data analysis programs on a regular basis, and generate reports.

Customer services should be specific and quantified as much as possible. For example, in a typical month, you may input 2 megabytes (MB) of data, spend 10 hours on database maintenance, use 30 minutes of Computer Processing Unit (CPU) time executing programs, and generate 50 pages of reports. Include other activities such as tape mounting, answering user queries, and cyclical fluctuations in services (i.e., year-end reports).

The system outputs and services for internal customers should be defined with the same precision used for external customers.

While this information provides the basis for identify benefits, most IT system and operational procedures do not explain how the services provided to customers helps them perform their function faster and/or better. That question is addressed in step 8, Estimating Benefits.

4.2.2 System Capabilities

System capabilities are the resources required to provide peak demand customer services. Some examples of system capabilities are:

- 100 megabytes of disk storage space
- Help Desk personnel to support 50 users
- Central Processing speed and communications lines to simultaneously support 30 on-line users
- Routine backup of user files and off-site storage of disaster recovery files
- 99% system availability during normal working hours
- Availability of monthly reports within two days of month end
- On-line access to 100 users
- One second response time for data entry and queries

4.2.3 System Architecture

The system architecture includes the hardware, software, communication links, and physical facilities required for systems operations. The documentation should go beyond a simple inventory to include other information necessary for determining systems costs and evaluating the future utility of individual items. The documentation should indicate whether items are owned or leased by the government, or owned or leased by a contractor.

For hardware, the following information is desirable:

- manufacturer
- make
- model
- year
- cost
- power requirements
- upgradability
- expected life
- maintenance requirements
- operating characteristics (e.g., screen size, lines per minute, CPU speed, memory size, hard drive capacity, sound capability)
- operating systems supported
- network operating systems supported

For software, the following information is desirable:

- manufacturer
- name
- version number
- year acquired
- license term
- hardware requirements
- cost (annual or purchase)

For physical facilities, the following information is desirable:

- location (address, room number)
- size (number of square feet)
- capacity (number of machines or people)
- type of structure (office, storage)
- availability (how long is it guaranteed?)
- annual cost

4.2.4 System Costs

The cost of the current system provides the baseline for the benefit cost analysis and must include all elements. The cost element table provided below addresses many of the cost elements for most systems. More detailed information on costs is addressed in step 7. A particular system may not include all elements identified within a particular category and may include some activities not shown.

Exhibit 1 - Cost Element Table

Cost Category	Cost Elements
Equipment, Leased or Purchased	Super-computers; mainframes; mini-computers; microcomputers; disk drives; tape drives; printers; telecommunications; voice and data networks; terminals; modems; data encryption devices; and facsimile equipment.
Software, Leased or purchased	Operating systems; utility programs; diagnostic programs; application programs; and commercial-off-the-shelf (COTS) software (word processing, communications, graphics, database management, and server software).
Services	Commercially provided services, such as teleprocessing, local batch processing, on-line processing, Internet access, electronic mail, voice mail, centrex, cellular telephone, facsimile, and packet switching of data.
Support services	Commercially provided services to support equipment, software, or services; such as maintenance, source data entry, training, planning, studies, facilities management, software development, system analysis and design, and computer performance evaluation and capacity management.
Supplies	Any consumable item designed specifically for use with equipment, software, services, or support services identified above.
Personnel (compensation and benefits)	Includes the salary (compensation) and benefits for government personnel (both civilian and/or military) who perform information technology functions 51% or more of their time. Functions include but are not limited to policy, management, systems development, operations, telecommunications, computer security, contracting, and secretarial support. Personnel in user organizations who simply use information technology assets incidental to the performance of their primary functions are not to be included.
Intra-governmental services	All information technology services within agencies, between executive branch agencies (e.g., FTS 2000), judicial and legislative branches, and State and local governments.

4.3 STEP 3 - ESTIMATE FUTURE REQUIREMENTS

Future customer requirements determine the system capabilities and architecture, and ultimately affect system costs and benefits. Thus, it is very important to accurately estimate the future requirements.

The two key items to consider are the system life cycle and the peak life cycle demands.

4.3.1 Determine Life Cycle Time

The first step is to determine how far into the future to plan. This period of time is called the life-cycle cost horizon or the system life cycle. The time period for the analyses of IT projects should cover the system life cycle. For this guidance, system life cycle includes the following activities:

- feasibility study
- design
- development
- implementation
- operation
- maintenance

A system life cycle ends when the system is terminated or is replaced by a system with significant changes in processing, operational capabilities, resource requirements, or system outputs. Some of the factors to consider are the speed of hardware and software changes, the probability of major changes in system requirements, and the estimated costs of maintaining the system. Large, complex systems should have a life cycle of at least five years, and the maximum length of time for a CBA should normally be no more than 10 or 12 years.

4.3.2 Estimate Life-Cycle Demands

The first step in estimating the user demands over the system life-cycle is to determine the best measures of the demand. Use those measures to determine what your demands were for several preceding years, calculate the change in demand from year to year, average this change, and use the average to make the predictions. For example, if you have averaged an increase in demand of 10 percent per year over the last five years, assume that this trend will continue, and demand will increase by 10 percent every year over the life cycle of the study. The example below uses one measure, and demonstrates a 10% average annual increase for the past four years.

Exhibit 2 - Average Annual Increase

Demand	1993	1994	1995	1996	1997
# of Users	1150	1275	1350	1550	1681
% Change		10.87%	5.88%	14.81%	8.45%
Average %					10.00%

The danger of this approach is that past history is not always a good indicator of the future. The mainframe computer centers that assumed mainframe usage would continue to increase in the 80's at the same rate as the 70's were not prepared for the PC explosion. Use this method when external factors have been evaluated to confirm that the past should be a good indicator of the future. Consult staff members who have been involved with the current system operation for a significant period of time.

A second method to determine life-cycle demands is to survey your customers. The advantage to the survey method is that it can identify major changes in customer requirements. Another possible outcome to a survey is that you will find that your customers have problems for which there is an IT solution. These "value added" solutions should be noted and quantified for inclusion under benefits. Surveying your customers properly requires time and expertise. Surveys must be prepared carefully and evaluated even more carefully to ensure that the results are interpreted properly. Consider hiring a professional survey organization unless in-house personnel with survey experience are available to perform the task or assist the CBA team.

In a complex situation that does not lend itself to the simple methods described above, sophisticated tools, such as time-series and regression analysis, can be used to forecast the future. Information on time series analysis can be found in books such as *Applied Forecasting Methods* by Nick Thomopoulos. A thorough treatment of regression analysis is provided by Norman Draper and Harry Smith in *Applied Regression Analysis*. Such tools should only be used by trained, experienced individuals.

4.3.3 Other Considerations

- If possible, make more than one forecast using different estimating methods. This will serve as a "sanity check" for the original forecast and add validity to the overall estimate.

- Include averages and peak demands in your estimates. If the system is not designed to meet peak demands, there must be a good reason (usually cost) not to do so.

- Use professional experience to temper the results of any forecast. Don't ignore this experience with regard to future demands and technology trends. Experience will enable you to identify and explore local IT issues and trends.

- Get feedback from other IT professionals on your estimates. Other analysts can point out potential shortcomings in the estimate or provide confirmation of methods and results.

- Try for an estimate range in addition to the point estimate. The point estimate is the basis for developing your alternative systems, but the high and low values are extremely important for the sensitivity analysis.

- Document everything. Good documentation backs up your estimates, thus minimizing uncertainty during reviews. The documentation will also facilitate the (inevitable) updates to the estimate.

4.4 STEP 4 - COLLECT COST DATA

Cost data must be collected for estimating the cost and benefits of each project alternative. Six sources of data are historical organization experience, current system costs, market research, publications, analyst judgment, and special studies. This is one of the most difficult steps in a CBA, but also on of the most important; the quality of your analysis is only as good as the quality of the

cost data.

4.4.1 Historical Organization Data

Historical contract data for an organization can be used to estimate the future purchase price of hardware, software, and services. If contracts were used to provide system support in the past, they can give you the costs for leasing and purchasing hardware and hourly rates for contractor personnel. Contracts for system support services for other systems in your organizations or other ICs can provide comparable cost data for the development and operation of a new system. The numbers will probably need to be adjusted to account for differing quantities and qualities for the proposed system. If necessary, adjust the cost to reflect current year price levels. Document all adjustments for future reference.

4.4.2 Current System Costs

The cost of your current computer system can be used to price similar alternatives. A study performed by the Department of Housing and Urban Development prior to their decision to outsource IT functions, for example, assumed percentage increases and decreases from their current system when estimating different alternatives. Appendix B, Baseline Cost Element Matrix, used for a Federal Aviation Administration study, is another example of using current system costs. Cost elements were addressed in Section 4.2.4 and will be addressed in more detail in Section 4.7

4.4.3 Market Research

Contact several sources to provide cost estimates for computer hardware, software, networks, user support, outsourcing, etc. Prepare clear, detailed performance requirements to be the basis for the estimates. Quotes from multiple sources (if possible) will provide an average figure that should be realistic price. Check the technical content and scope of the quotes: low estimates may be omitting some necessary (and costly) services. Also remember that a vendor quote is not usually prepared with the same level of effort as a bid on a contract.

Vendors are usually happy to provide cost information because it gives them an opportunity to market their services. Be sure to let them know you are only looking for generic cost data for planning and analysis purposes, and that no procurement is planned at the present time. Organizations such as the Gartner Group and IDC Government can also provide assistance in developing cost data.

The government-wide agency contracts (GWACS) are also good sources of current cost data for personnel, hardware, and software. The CIT Web site for IT Acquisitions (**URL =** http://www.cit.nih.gov/acqs.html provides access to a variety of procurement vehicles.

4.4.4 Publications

Trade journals and industry publications are also good sources of cost data. Trade journals usually conduct annual surveys that provide general cost data for IT personnel. Included in this category are government sources such as the General Services Administration (GSA) pricing schedule. The Supplement to the Office of Management **(OMB) Circular A-76, "Performance of Commercial Activities,"** provides inflation rates and tax rates.

4.4.5 Analyst Judgment

In some cases, data may not be available to provide an adequate cost estimate. In that situation, the best alternative is to use the judgment and experience of CBA team members to estimate costs. To provide a check against the team's estimates, discuss them with other IT professionals, both in government and industry. These discussions can highlight the strengths and weaknesses of the estimating logic and provide alternative estimates for comparison. Detailed documentation very important, because it will facilitate your discussions with others and renders a history for later verification and validation.

Analyst judgment is also a legitimate tool for evaluating costs obtained through other means. The team's experience and knowledge must ensure that data gathered from other sources is applicable to the cost being estimated, and that the data is applied correctly.

4.4.6 Special Studies

Special studies are sometimes done to collect cost data for large IT projects. For example, the Federal Aviation Administration (FAA), which outsourced its data centers, used three different in-house studies to provide costs for software conversion, internal operations, and potential benefits. These data sources became the foundation of the FAA benefit-cost analysis. While the number and scope of the studies may seem excessive, the FAA was trying to gather as much information as possible before deciding how to spend hundreds of millions on automated data processing. Such studies are not feasible for a quick analysis, but should be considered before committing to outsourcing or other large, mission-critical projects.

4.5 STEP 5 - CHOOSE AT LEAST THREE ALTERNATIVES

A CBA must present at least three alternatives. One alternative that should be always be included in the CBA is to continue with no change. During the Work Process Evaluation, a number of alternatives may be considered. Other alternatives are whether to do development, operations, and maintenance with in-house personnel or contractors. Each technical approach that is a viable alternative from a work process perspective should be included as an alternative. However, the number of technical approaches may be limited if only one or two are compatible with the NIH IT architecture. Some alternatives can be addressed and rejected because they are not feasible for reasons other than costs and benefits.

Management has probably decided that the no change alternative is unacceptable, or you wouldn't be looking at other alternatives; however, the costs and benefits of that alternative may not have been

documented. Including that alternative should prove that it is not the best alternative. If there are other factors that make the no change alternative unacceptable, that can be documented, and it would not be necessary to compare its costs and benefits against the feasible alternatives.

During the early stages of an IT project, there are many alternatives to be considered. This is particularly true during the Work Process Evaluation. If the work process is operating in a manner that makes maximum use of IT to maximize its efficiency and effectiveness, the process may not need to be changed. If the process can be changed to take advantage of IT, there may be two or more alternatives that appear to be feasible. If so, they may be alternatives that should be included in the CBA.

The development, operation and maintenance can be done either with in-house personnel or contractors, providing several potential, competing alternatives. The decision to use in-house resources or contractor resources is often a case where in-house resources are not available, so only one alternative may be feasible for the CBA. If that is the case, it should be documented.

When considering the potential use of contractors, it should be noted that, technically, a decision to contract out a specific function must be made following the guidelines in **OMB Circular No. A-76, Performance of Commercial Activities**. Using a contractor to develop, maintain or operate an IT system does not normally require an A-76 study, but the circular does contain guidance on determining in-house costs that would be pertinent to a CBA alternative.

Any IT project that involves acquiring equipment should consider the alternatives of leasing and purchasing. With the rapid changes in technology, the useful life of desktop PCs has been reduced to less than 5 years. **OMB Circular A-94**, Section 13, specifically addresses lease-purchase analysis, and is included here as Appendix C.

4.6 STEP 6 - DOCUMENT CBA ASSUMPTIONS

Because a CBA often relies on many assumptions, it is important to document all of them, and, if possible, justify them on the basis of prior experiences or actual data. For example, you may assume that the PC hardware and software for a system will need to be upgraded every three years. This could be justified on the basis of the rapid increases in capacity and speed and decreases in cost for PCs over the past 15 years.

This can also be an opportunity to explain why some alternatives were not included in the analysis. Some alternatives are eliminated in the early stages of a CBA because of a conclusion that it is not feasible. If that conclusion is based on an assumption, the assumption must be clearly explained and justified.

4.7 STEP 7 - ESTIMATE COSTS

Many factors must be considered during the process of estimating the costs associated with competing alternatives in a CBA. All costs for the full system life cycle for each competing alternative must be included. The following factors must be addressed: Activities and Resources,

4.7.1 Activities and Resources

maintenance of an IT system. One approach is to identify the activities performed and estimate the cost of the resources associated with each activity. The activities identified below (or

associated with the activities listed below are addressed in the **NIH IT Management Guide**

- **Problem Definition**
- **Work Process Evaluation**
- **Processing Requirements Definition**
- **Security Planning**
- **IT Performance Measure Development**
- **Cost Benefit Analysis**
- **IT Investment Review**
- **IT Resources Acquisition**
- **System Implementation**
  - **Design**
  - **Operation**
  - **Maintenance**
- **System Performance Evaluation**

A sample list of activities and the required resources (cost elements) is provided below.

Exhibit 3 - System Life-Cycle Cost Matrix

ACTIVITY	TASK	COST ELEMENTS
Project Initiation	Problem Definition	Analysts*, Managers, Processors**, Customers
	Work Process Evaluation	Analysts, Managers, Processors, Customers
	Processing Requirements Definition	Analysts, Managers, Processors, Customers
	Security Planning	Analysts, Managers, Processors, Customers
	Develop IT Performance Measures	Analysts, Managers, Processors, Customers
	Prepare Cost Benefit Analysis	Analysts, Managers, Processors, Customers
IT Resources Acquisition	Develop Statement of Work	Analysts, Managers, Processors, Customers
	Award Contract	Project Manager, Analysts, Contracting Personnel
	Monitor Contract	Project Manager, Contracting and Finance Personnel
System Design	Develop System Design	Analysts, Managers, Processors

	Approve System Design	Analysts, Managers, Processors
System Development	Develop and Test Programs and Procedures	Analysts, Managers, Processors, Programmers, Computers, Software
	Develop Transition Plan	Analysts, Managers, Processors,
	Implement New System & Procedures	Analysts, Managers, Processors, Programmers, Computers, Software
System Operation	Operate New System	Analysts, Managers, Processors, Programmers, Computers, Software
System Maintenance	Correct Errors & Make Changes to the System	Analysts, Managers, Processors, Programmers, Computers, Software
System Evaluation	Evaluate System Performance Compared to Expectations	Analysts, Managers, Processors, Customers
System Management	Oversee System	Project Manager, Managers

* Analysts will usually be Management Analysts and/or Computer Systems Analysts.

** Processors are the people in the organization performing the work process that is being automated. Statisticians and/or economists may be required for the cost-benefit analyses.

It should be noted that supplies will probably be required for each activity.

4.7.2 Cost Categories

Costs should be identified in a way that relates to the budget and accounting processes. The cost categories table from an old version of **OMB Circular A-11** (included as Appendix D) provides a definition and sample items for each category and identifies the object class codes that should be used to record costs in the accounting system.

4.7.3 Personnel Costs[6]

OMB recommends that prevailing wage rates and salaries be used to determine personnel costs. For direct labor rates, use the salaries for step 5 of the General Schedule (GS) positions and step 4 for Wage Grade (WG) positions. As a rule, GS salary is expressed as an annual rate of pay; WG salary is expressed as an hourly rate. For positions to be used on a prearranged regularly scheduled tour of duty, this hourly rate is multiplied by 2,087, the number of hours employees are paid annually.

Estimate the following fringe benefit factors according to the Federal Accounting Standards for Liabilities-Exposure:

[6] Details on personnel costs can be found in the **OMB Circular A-76 Supplemental Handbook, PART II**--Preparing the Cost Comparison Estimates.

(1) The total fringe benefit factor for full or part-time permanent Federal civilian employees is **32.45%**, broken down as follows:

(a) The standard retirement cost factor represents the Federal Government's complete share of the weighted CSRS/FERS retirement cost to the Government, based upon the full dynamic normal cost of the retirement systems; the normal cost of accruing retiree health benefits based on average participation rates; Social Security; and Thrift Savings Plan (TSP) contributions. The 1996 rate was **23.7%** of base payroll for all agencies. The comparable retirement cost factors for special class employees are 32.3% for air traffic controllers and 37.7% for law enforcement and fire protection employees.

(b) The cost factor to be used for Federal employee insurance and health benefits, based on actual cost, is **5.6%**, plus an additional **1.45%** for Medicare.

(c) The cost factor to be used for Federal employee miscellaneous fringe benefits (workmen's compensation, bonuses and awards, and unemployment programs) is **1.7%**.

(2) Intermittent or temporary Federal civilian employees.--The Federal Insurance Contribution Act (FICA) employer cost factor of **7.65** (or the current rate established by law) will be applied to civilian employees not covered by either of the two civilian civil service retirement systems (normally intermittent and temporary employees). Apply the FICA rate only to wages and salaries subject to the tax; there is an annual salary limitation for FICA tax.

Example: The 1998 annual salary for a GS-13 employee, step 5, working in the Washington - Baltimore area is $63,431. The annual fringe benefits cost is computed by multiplying the annual salary($63,431) by .3245, which equals $20,583.36.

4.7.4 Indirect Costs

Direct costs, such as direct labor and direct material, are costs incurred in a process that is “hands on,” that directly produces the output. Indirect costs (often referred to as overhead costs) are incurred in a support role (all costs that are not direct). Typical overhead items are indirect labor, indirect material, and fixed costs such as rent, depreciation, advertising, taxes, utilities, and insurance. Overhead is often expressed as a percentage of direct labor. For example, if an organization has $50,000 of direct labor costs and the overhead costs are $10,000, the overhead rate would be 20% ((10,000/50,000) x 100).

Overhead in the Federal government normally includes two major categories of cost:

- Operations Overhead is defined as those costs that are not 100 percent attributable to the activity under study, but that are generally associated with the recurring management or support of the activity.

- General and Administrative Overhead includes salaries, equipment, space and other activities related to headquarters management, accounting, personnel, legal support, data processing management and similar common services performed outside the activity, but in support of it

OMB Circular A-76 specifies 12% as the overhead rate (see 3/96 Supplemental Handbook, Chapter II (Preparing the Cost Comparison Estimates), Section E (Overhead - Line 4)).

To determine the "fully burdened" cost of a government employee, add the overhead costs to the cost of the salary and fringe benefits. In the case of the GS-13, discussed above under Personnel Costs, the annual salary of $63,431 plus fringe benefits of $20,583.36 equals $84,014.36. Overhead is computed by multiplying $84,014.36 by .12, giving $10,081.72. Adding the overhead gives a "fully burdened" cost of $94,096.08. The general formula for the total/fully burdened annual cost would be Direct Annual Salary x 1.48344 (the 1.48344 is equal to 1.3245 x 1.12). The hourly costs can be computed by dividing the annual costs by 2,087.

4.7.5 Depreciation

Depreciation is defined as lowering the estimated value (referred to as book value) of a capital asset (usually only those items valued at $1,000 or more). Depreciation is also defined as the method used to spread the cost of tangible capital assets over an asset's useful life (the number of years it functions as designed). It is computed by comparing the original cost (or value) with the estimated value when it can no longer perform the function(s) for which it was designed, its residual or salvage value. There are a number of ways to compute depreciation, but OMB prefers that straight-line depreciation be used for capital assets.

Exhibit 4, Tangible Asset Depreciation, illustrates straight-line depreciation of a $10,000 asset with a useful life of 5 years, and a residual or salvage value of $1,000. The computation includes the following steps:

1. Subtract the residual value from the book value to get the depreciation amount. ($10,000 - $1,000 = $9,000)
2. Divide depreciation amount by the useful life to compute annual depreciation amount. ($9,000/5 years = $1,800/year)
3 The book value at the end of each year is computed by subtracting the annual depreciation from the book value at the beginning of the year. For example, the book value at the end of Year 1 is $8,200 ($10,000 -$1,800). A full depreciation table is shown below.

Exhibit 4, Tangible Asset Depreciation

Year	0	1	2	3	4	5
Annual Depreciation		$1,800	$1,800	$1,800	$1,800	$1,800
Book Value	$10,000	$8,200	$6,400	$4,600	$2,800	$1,000

4.7.6 Annual Costs

All cost elements must be identified and estimated for each year of the system life cycle. This is necessary for planning and budget considerations. Exhibit 5, Activity Cost Matrix, illustrates the cost estimates for the Project Initiation activity for a project.

Exhibit 5, Activity Cost Matrix

Activity	Task	Hardware	Software	Services (Commercial)	Support Services	Supplies	Personnel (In-house)	Inter-Agency Services	Total Cost
Project Initiation (Startup)	Problem Definition						5,000		5,000
	Wrk Proc Eval.				10,000	100	10,000		20,100
	Require Defin.				4,000	100	6,000		10,100
	Security Plan				1,000		500		1,500
	Perf. Measures				6,000	100	5,000		11,100
	Cost Ben Analysis				3,000	100	8,000		11,100
Activity Total		0	0	0	24,000	400	34,500	0	58,900

The Support Services costs are for a contractor providing assistance with five different tasks. The in-house personnel costs are for analysts, managers, processing personnel, and customers involved in the various tasks. No hardware, software, commercial services, or inter-agency costs were incurred for the tasks that made up this activity example, but they could be in a real situation.

Exhibit 6, Annual Cost Matrix, below, illustrates estimated annual costs over the life of a 10-year IT project. In the first year in-house staff and contractors define the problem, evaluate the work process, define processing requirements, prepare the cost-benefit analysis, develop a request for proposals (RFP), and issue a contract for the development of the system. The second year a contractor will design and implement the system. The next eight years reflect operational and maintenance costs for equipment, software, in-house personnel, and contractor personnel. Years five and six also reflect in-house acquisition costs for establishing a new five year contract for maintenance of the system and help desk support.

Exhibit 6, Annual Cost Matrix

Year	Startup	Acquisition	Development	Operation	Maintenance	Total
1	100,000	100,000				200,000
2			800,000			800,000
3				200,000	80,000	280,000
4				200,000	60,000	260,000
5		50,000		200,000	50,000	300,000
6		50,000		200,000	50,000	300,000
7				200,000	40,000	240,000
8				200,000	30,000	230,000
9				200,000	30,000	230,000
10				200,000	30,000	230,000
Total	100,000	200,000	800,000	1,600,000	370,000	3,070,000

4.8 STEP 8 - ESTIMATE BENEFITS

Identifying and estimating the value of benefits will probably be the most difficult task in the CBA process. Six specific activities are addressed in this section.

4.8.1 Define Benefits

Benefits are the services, capabilities, and qualities of each alternative system, and can be viewed as the return on investment (ROI). Webster uses such terms as advantage, useful aid, help, and service to define it. Some examples of benefits for IT systems are:

- **Accuracy** - Will the proposed system provide better accuracy by reducing the number of data entry errors or eliminate some data entry that would, in turn, result in fewer data entry errors?
- **Availability** - How long will it take to develop and implement the system? Will one alternative be available sooner than other?
- **Compatibility** - How compatible is the proposed alternative with existing facilities and procedures? Will one alternative require less training of personnel or less new equipment or software?
- **Efficiency** - Will one alternative provide faster or more accurate processing of inputs? Will one alternative require fewer resources for the processing?
- **Maintainability** - Will the maintenance costs for one alternative be less than the others? Are the maintenance resources easier to acquire for one alternative? An example of this would be availability and cost of programmers to maintain the software.
- **Modularity** - Will the software for one alternative be more modular than the other alternatives? Greater modularity can reduce maintenance costs and may increase the portability of the software.
- **Reliability** - Does one alternative provide greater hardware or software reliability? Greater reliability translates to higher productivity in using and/or operating the system and less time for operations and user support.
- **Security** - Does one alternative provide better security to prevent fraud, waste or abuse? Are privacy, confidentiality, and data integrity enhanced?

4.8.2 Identify Benefits

Every proposed IT system for an organization should have identifiable benefits for both the organization and its customers. Identifying these benefits will usually require an understanding of the work processes of the organization and its customers. Normally, the benefits to the customers will be much less than the benefits for the organization that is developing the system.

Some benefits for the provider organization could include flexibility, organizational strategy, risk management and control, organizational changes, and staffing impacts. New IT systems may allow some personnel to perform two different jobs with little or no extra training; or the new system may allow organizational changes that reduce the number of managers, or the new system may allow some jobs to be eliminated entirely. These benefits are often measured in terms of productivity gains, staffing reductions, and improved organizational effectiveness.

Possible benefits to customers include improvements to the current IT services and the addition of new services. These benefits can be measured in terms of productivity gains and cost savings, but the customers must be the ones to identify and determine how to measure and evaluate the benefits. Customer surveys are often needed to identify these benefits. At a minimum, the customers should be interviewed to identify the potential impacts of new or modified systems.

Many of the benefits discussed here are very general, and, in actual practice, they will need to be defined more precisely. For example, the benefits of greater accuracy may be defined as in terms of reduced personnel costs for data entry, error detection, and correction of errors.

4.8.3 Establish Measurement Criteria

Establishing measurement criteria for benefits is crucial because of the Government Performance and Results Act (GPRA) and the Information Technology Management Reform Act (ITMRA). These Acts both emphasize having tangible measures of success (benefits) that are related to the overall mission and goals of the organization.

Establishing performance measures is a difficult task, especially for an activity that is in the planning stage. Fortunately, most IT systems have similar systems that can be used as guides for measuring benefits. The CIT Web site has a Performance Measures site (http://irm.cit.nih.gov/itmra/perfmeasure.html) that provides a wide range of documents and links to other sites with information related to performance measures. Some general concepts relating to performance measures are addressed below.

Some of the generic performance measures used to account for the value and impact of information technology are:

- Improvements in process/product/service
- Cycle time reduction
- Customer Satisfaction
- Cost-effectiveness

The National Academy of Public Administration (NAPA) performed a study for the Department of Defense (DOD) and identified the following generic information management performance measures:

- Percent change in life cycle costs
- Percent change in work process cycle time
- Percent change in acquisition time to deliver a product or service
- Percent change in functional products/services quality (e.g., fewer errors in transactions)
- Percent change in satisfied customers
- Percent change in major automated information systems projects that are on schedule, within budget, and achieve expected results
- Percent change in systems that comply with architectures and standards
- Percentage of systems project management staff which meet acquisition and information management education and training requirements

Some of the “Lessons Learned” by NAPA are:

- Involve key stakeholders
- Focus first on most costly or troubled programs
- Develop measures in the context of goal setting (plans) & management controls (budgets)

- Choose measures that are outcome-oriented, quantifiable, and can demonstrate value
- Select a "vital few" (concentrate on 3 or 4 good measures)
- Do not overpromise
- Educate and train stakeholders in performance measurements

4.8.4 Classify Benefits

Benefits that are "capable of being appraised at an actual or approximate value" are called **tangible benefits**. Benefits that cannot be assigned a dollar value are called **intangible benefits**. A good example of a tangible benefit is lower hardware costs; it is the difference between two dollar values for hardware. By subtracting the cost of hardware for the proposed system ($100,000) from the cost of the current system hardware ($150,000) we compute a savings (benefit) of $50,000. An example of an intangible benefit is flexibility. A proposed system may allow a manager to have two or three different people perform the same job without significant training expense. This could keep a system operational if one or more employees were out of the office for a period of time, but it would be impossible to assign a realistic dollar value to that capability. The value would depend on the impact of a portion of a system being inoperable for a period of time, the length of that time, and the frequency of that situation occurring.

4.8.5 Estimate Tangible Benefits

The process of estimating the dollar value of a benefit is similar to the cost estimation process discussed in the previous section. The dollar value of benefits can be estimated by determining the fair market of the benefits. These dollar values are then assigned to the year in which the benefits will occur. If a benefit cannot be associated with a particular year, and that benefit is expected to be realized over the life-cycle of the study, you may allocate the dollar value of the benefit equally to each year of the study. The benefit value may also be assigned to specific years with different values for each year.

Market Research quotes can also be useful in determining benefit value. An important economic principle used in estimating public benefits is the market value concept. Market value is the price that a private sector organization would pay to purchase a product or service. When valuing new services that an upgraded IT system could provide, it may be useful to determine how much a company would charge to provide such a service. When increased productivity or reductions in personnel are the projected benefits, the value of the personnel time can be computed just as systems costs for personnel are computed.

4.8.6 Quantify Intangible Benefits

Intangible benefits can be quantified using a subjective, qualitative rating system. A typical qualitative rating system might evaluate potential benefits against the following five criteria:

(1) Provides Maximum Benefits (2 points)
(2) Provides Some Benefits (1 point)

(3) Provides No Benefits (0 points)
(4) Provides Some Negative Benefits (-1 point)
(5) Provides Maximum Negative Benefits (-2 points)

Other scales use three or four evaluation criteria, and make no provision for negative benefits. The rating criteria can be used to enable numerical comparisons between alternatives. For the above criteria, another possible scale would be 10, 5, 0, -5 -10 instead of 2, 1, 0, -1, -2.

Once the rating system is selected, each benefit is evaluated for each of the alternatives. This should be done by a group of individuals familiar with the current IT system and the alternatives being evaluated. Having five people do the evaluation would be ideal, and three evaluators should be a bare minimum. A large sample will "average out" individual preferences and perceptions. The numerical values assigned to the ratings then can be summed and averaged to obtain a score for each benefit. Exhibit 7, Quantify Benefits, shows the scores for benefits A - G from four reviewers using a scale of 1 to 5.

Exhibit 7, Quantify Benefits

Benefit	Reviewer 1 Score	Reviewer 2 Score	Reviewer 3 Score	Reviewer 4 Score	Reviewer Average Score
A	5	4	3	5	4.25
B	4	2	3	4	3.25
C	3	2	5	4	3.50
D	4	3	2	2	2.75
E	2	3	1	4	2.50
F	3	4	5	3	3.75
G	2	4	5	3	3.50

An option that can be used in a qualitative assessment is to "weight" each of the benefit criteria with regards to importance. The more important the benefit, the higher the weight. The advantage of weighting is that the more important benefits have a greater influence on the outcome of the benefit analysis. The weighting scale can vary between any two predetermined high and low weights. An example of calculating a weighted score is given below. Exhibit 8, Weighted Scoring, shows the scores for benefits A through G for two alternatives of a CBA and demonstrates that the use of weighting factors makes Alternative 1 the clear winner.

Exhibit 8, Weighted Scoring

Benefit	Alternative 1 Raw Score	Alternative 2 Raw Score	Weighting Factor	Alternative 1 Weighted Score	Alternative 2 Weighted Score
A	4	2	10	40	20
B	3	3	9	27	27
C	3	2	9	27	18
D	4	3	8	32	24
E	2	3	6	12	18
F	3	4	5	15	20
G	2	4	5	10	20
TOTAL	21	21		163	147

4.9 STEP 9 - DISCOUNT COSTS AND BENEFITS

After the costs and benefits for each year of the system life cycle have been identified, convert them to a common unit of measurement for comparing competing alternatives. That is accomplished by discounting future dollar values, thus transforming future benefits and costs to their "present value." The present value (also referred to as the discounted value) of a future amount is calculated with the following formula:

$$\mathbf{P = F\ (1/(1+I)^n)}$$

where P = Present Value,
F = Future Value,
I = Interest Rate, and
n = number of years.

The term Discount Factor is used for $1/(1+I)^n$. Present values can be calculated by multiplying the future value times the Discount Factor instead of using the entire formula. The Discount Factors are published in the **OMB Circular A-94**, and include the discount factors from 1 to 30 years for discounting at the beginning of the year, the end of the year, and the middle of the year. The formula $1/(1+I)^n$ is used when the assumption is that costs and benefits occur as lump sums at year-end. The formula for the mid-year Discount Factor is $1/(1+I)^{n-.5}$. The formula for the Discount Factor/Rate when costs and benefits occur as lump sums at the beginning of the year is $1/(1+I)^{n-1}$. Appendix E is a table containing all three discount factors when 7% (.07) is the Interest Rate.

Exhibit 9, Discounted Costs and Benefits, shows the annual costs and benefits for the life cycle of a system, along with the discount factor, the discounted costs and benefits (present values), and the discounted net (net present value). The discounted costs and benefits are computed by multiplying the costs and benefits by the discount factor. Since costs and benefits often occur in a steady stream, mid-year discount factors are used. The net benefit without discounting is $380,000 ($3,200,000 - $2,800,00) while the discounted (present value) net is under $60,000 because the biggest costs are incurred in the first two years, while the benefits are not accrued until the third year.

Exhibit 9, Discounted Costs and Benefits

Year	Annual Cost	Annual Benefit	Discount Factor	Discounted Cost (DC)	Discounted Benefit (DB)	Discounted Net
	AC	AB	DF	ACxDF	ABxDF	DB-DC
1	150,000		0.9667	145,010	-	(145,010)
2	600,000		0.9035	542,095	-	(542,095)
3	280,000	400,000	0.8444	236,428	337,754	101,326
4	260,000	400,000	0.7891	205,178	315,658	110,480
5	300,000	400,000	0.7375	221,256	295,007	73,752
6	300,000	400,000	0.6893	206,781	275,708	68,927
7	240,000	400,000	0.6442	154,603	257,671	103,068
8	230,000	400,000	0.6020	138,468	240,814	102,346
9	230,000	400,000	0.5626	129,409	225,060	95,650
10	230,000	400,000	0.5258	120,943	210,336	89,393
Total	2,820,000	3,200,000		2,100,171	2,158,008	57,837

4.10 STEP 10 - EVALUATE ALTERNATIVES

While most costs can be quantified in dollar terms, many benefits cannot. As a result, evaluating alternatives cannot always be done using present values of the costs and benefits; however, valid evaluations can still be made using a combination of dollar values and quantified relative values. that are numeric, but do not represent dollar values.

4.10.1 Evaluate With All Dollar Values

When all of the costs and benefits for each competing alternative have been assigned dollar values and discounted, the net present value of the alternatives should be compared and ranked. When the alternative with the lowest discounted cost provides the highest discounted benefit, it is the clear winner, as shown in Exhibit 10.

Exhibit 10, A Clear Winner

Alternative	Discounted Cost (DC)	Discounted Benefit (DB)	Discounted Net (DB-DC)	Benefit to Cost Ratio (DB/DC)
1	1,800,000	2,200,000	400,000	1.22
2	1,850,000	1,750,000	(100,000)	0.95
3	2,000,000	2,000,000	-	1.00
4	2,200,000	2,100,000	(100,000)	0.95

Discounted Net

There will probably be very few cases where the alternative with the lowest discounted cost provides the highest discounted benefit. The next number to consider is the Discounted Net (Discounted Benefit minus Discounted Cost). If one alternative clearly has the highest Discounted Net, it could be considered the best alternative; however, it is usually advisable to look at other factors. Exhibit 11, No Clear Winner, the example provided below, illustrates the complexity of using just the Discounted Net as the basis for determining the best alternative.

Alternative 1 has the lowest discounted cost, but it also has the lowest discounted benefit. Alternative 2 has a low discounted cost (but not the lowest) but its discounted benefits are relatively low. Alternative 3 is clearly unacceptable because the discounted net is negative. Alternatives 4 and 5 are both highly desirable because they have the highest discounted nets, but they are also the most costly. Alternative 5 has the highest Discounted Net, but there may not be $2,500,000 in the budget. Also, compared to Alternative 4, you have to $250,000 more to get $300,000 worth of additional benefits.

Exhibit 11, No Clear Winner

Alternative	Discounted Cost (DC)	Discounted Benefit (DB)	Discounted Net (DB-DC)	Benefit to Cost Ratio (DB/DC)
1	1,500,000	1,600,000	100,000	1.07
2	1,600,000	1,750,000	150,000	1.09
3	2,000,000	1,800,000	(200,000)	0.90
4	2,250,000	2,500,000	250,000	1.11
5	2,500,000	2,800,000	300,000	1.12

Benefit to Cost Ratio

When the alternative with the highest discounted net is not a clear winner, the **benefit to cost ratio** (discounted benefit divided by discounted cost) may be used to differentiate between alternatives with very similar or equal Discounted Nets. In Exhibit 12, Best Benefit to Cost Ratio, Alternative 4 would be the winner because it has a higher benefit to cost ratio than Alternative 5. Alternatives 4 and 5 are clearly superior to the other alternatives because they have the highest discounted net.

Exhibit 12, Best Benefit to Cost Ratio

Alternative	Discounted Cost (DC)	Discounted Benefit (DB)	Discounted Net (DB-DC)	Benefit to Cost Ratio (DB/DC)
1	1,500,000	1,600,000	100,000	1.07
2	1,600,000	1,750,000	150,000	1.09
3	1,900,000	2,000,000	100,000	1.05
4	2,000,000	2,450,000	450,000	1.23
5	3,000,000	3,450,000	450,000	1.15

Incremental Benefit to Cost Ratio

Another technique is to use the **incremental benefit to cost ratio**. The following exhibits show how this technique would identify the best alternative. Exhibit 13, Equal Benefit to Cost Ratios, illustrates an analysis where the two best alternatives have the same Discounted Net and almost identical benefit to cost ratios, but one alternative has to be selected.

Exhibit 13, Equal Benefit to Cost Ratios

Alternative	Discounted Cost (DC)	Discounted Benefit (DB)	Discounted Net (DB-DC)	Benefit to Cost Ratio (DB/DC)
1	1,500,000	1,600,000	100,000	1.07
2	1,600,000	1,750,000	150,000	1.09
3	2,000,000	1,800,000	(200,000)	0.90
4	2,255,000	2,805,000	550,000	1.24
5	2,500,000	3,050,000	550,000	1.22

Exhibit 14, Incremental Benefit-Cost Ratio, shows how comparing the increased costs with the associated increased benefits (relative to the lowest cost alternative) can identify the best alternative of two or more with the same benefit-cost ratio.

The first step is to order the alternatives by discounted cost, lowest to highest.

The next step is to calculate the changes in discounted costs and benefit scores. The increases in discounted costs and benefits are computed by subtracting the discounted costs and benefits of Alternative 1 from the discounted costs and benefits of Alternatives 2, 3, 4, and 5 (n).

For Alternative 4, spending an additional $750,000 to increase the benefits by $1,205,000 gives a gain in the discounted net of $450,000. This gives an incremental benefit to cost ratio of 1.60. By comparison, Alternative 5 gives an incremental benefit to cost ratio of only 1.45, making Alternative 4 the best alternative.

Alternative 2 has an incremental benefit to cost ratio of 1.5; which is higher than the 1.45 of Alternative 5; however; Alternative 5 would still be a better alternative because its Discounted Net and incremental discounted net are greater than the same values for Alternative 2.

Exhibit 14, Incremental Benefit-Cost Ratio

Alternative (n)	Increase in Discounted Cost (IDC) (DC, Alt. n - DC, Alt. 1)	Increase in Discounted Benefit (IDB) (DB, Alt. n - DB, Alt. 1)	Incremental Discounted Net (IDB - IDC)	Incremental Benefit to Cost Ratio (IDB/IDC)
2	100,000	150,000	50,000	1.50
3	500,000	200,000	(300,000)	0.40
4	755,000	1,205,000	450,000	1.60
5	1,000,000	1,450,000	450,000	1.45

Other Considerations

Budget considerations may override the discounted net and the benefit to cost ratio when determining the best alternative. In the previous example, the cost-benefit analysis could be used to increase the budget for a project to $2,255,000; however, if the budget falls between

$1,500,000 and $2,025,000, the best alternative would be 2, with a cost of $1,600,000, a discounted net of $150,000, and a cost-benefit ratio of 1.09. **An effective cost-benefit analysis may be used to demonstrate that there is a good justification for increasing the $1,600,000 to $2,250,000.**

4.10.2 Evaluate With Intangible Benefits

When all of the benefits are intangible, assign relative numerical values as addressed in section 4.8.6, Quantify Relative Benefits. After the costs have been discounted and the benefits have been quantified, the costs and benefits can be compared and ranked.

Direct Compare

The simplest way to evaluate alternatives is to directly compare the costs and benefits. In Scenario 1, Exhibit 15, Relative Benefit Comparison, Alternatives 1 and 5 have the highest relative benefit scores. Alternative 1 would be the clear winner for Scenario 1 because it has the lowest cost and the highest benefit. Scenario 2 shows a more common situation where the benefits increase with the higher costs, and there is no clear winner without further analysis.

Exhibit 15, Relative Benefit Comparison

Alternative	Discounted Cost	Benefit Score Scenario 1	Benefit Score Scenario 2
1	1,500,000	2.20	2.20
2	1,600,000	2.10	2.30
3	2,000,000	2.00	3.50
4	2,250,000	2.10	4.00
5	2,500,000	2.20	4.25

Compare Increases in Costs and Benefits

One way to evaluate the alternatives shown in Scenario 2, Exhibit 15, is to compare the increases in costs and benefits relative to the lowest cost alternative. The first step is to order the alternative systems by discounted cost, lowest to highest.

The second step is to calculate the changes in discounted costs and benefit scores. The Cost Change is computed by subtracting the lowest valued cost alternative from the higher valued cost alternative (See Exhibit 16, Percentage Increase Ratio). The Benefit Change is computed in the same manner.

The third step is to compute the percentage of change for the costs and benefits of the different alternatives. The percentage Cost Change for each alternative is computed by dividing the Cost Change by the lowest valued cost alternative (number 1) and multiplying that number by 100 to convert it to a percentage. The % Benefit Change is calculated in the same manner using Benefit Change instead of Cost Change.

The final step is to compute the percentage increase ratio for each alternative by dividing the , % Benefit Change by the % Cost Change. The best alternative would then be the one with the highest percentage increase ratio. In this example, the ratio of the % Benefit Change to the % Cost Change is highest for Alternative 3. The ratio for Alternative 4 is only .13 less than the ration for Alternative 3, indicating there is very little difference between the two alternatives. This may be a situation where other factors, such as the amount of funds available, technical risk, or scheduling differences, might be used to finally determine the best alternative.

Exhibit 16, Percentage Increase Ratio

Alternative (n)	Discounted Cost (DC)	Benefit Rating (BR)	Benefit Change (BC) BR(n)-BR(1)	Cost Change (CC) DC(n)-DC(1)	% Benefit Change (%BC) BC/BR(1)	% Cost Change (%CC) CC/DC(1)	% Increase Ratio %BC/%CC
1	1,500,000	2.20					
2	1,600,000	2.30	0.10	100,000	5%	7%	0.68
3	2,000,000	3.50	1.30	500,000	59%	33%	1.77
4	2,250,000	4.00	1.80	750,000	82%	50%	1.64
5	2,500,000	4.25	2.05	1,000,000	93%	67%	1.40

Convert Costs to Relative Values

A relatively simple comparison technique is to convert the cost estimates to relative values that are comparable to the relative values for the benefits. The first step is to establish a range of relative values from one to ten or one to 100 to allow the differences in the alternative scores to be relatively significant. The dollar cost values will always have to be converted to the new relative values, but the original benefit values will have to be converted to the new scale only if their range of values is different than the new range of values. Exhibit 17, Conversion Table, shows the Discounted Cost being divided by 100,000 and the Benefit Ratings being multiplied by 10 to get comparable values. The 10,000 and 10 are arbitrary numbers, and using 100,000 and 1 would produce basically the same results.

Exhibit 17, Conversion Table

Alternative	Discounted Cost (DC)	Conversion Factor (CF) 1/100,000	Converted Cost (CC) DCxCF	Benefit Rating (BR)	Conversion Factor (CF) 10	Converted Benefit BRxCF
1	1,500,000	0.00001	15.00	2.20	10	22.00
2	1,600,000	0.00001	16.00	2.30	10	23.00
3	2,000,000	0.00001	20.00	3.50	10	35.00
4	2,250,000	0.00001	22.50	4.00	10	40.00
5	2,500,000	0.00001	25.00	4.25	10	42.50

After the conversion has been completed, the evaluation can be done as shown in Exhibit 18, Relative Value Comparison. In this example, the best alternative would be Alternative 4, which has the highest Benefit-Cost Ratio by a very small margin over Alternative 3.

Exhibit 18, Relative Value Comparison

Alternative	Converted Cost (CC)	Converted Benefit (CB)	Benefit To Cost Ratio CB/CC
1	15.00	22.00	1.47
2	16.00	23.00	1.44
3	20.00	35.00	1.75
4	22.50	40.00	1.78
5	25.00	42.50	1.70

The two techniques just discussed both show alternatives 3 and 4 to be clearly the two best alternatives. The fact that different alternatives could be selected using the two different techniques is an indication that the numbers are so close for the two alternatives that there is not a clear difference between them from a cost and benefit perspective. This is clearly a situation where either alternative could be selected, and justified, or other factors could be used as tie breakers.

4.10.3 Evaluate With Combination

In many cases, proposed systems will have both tangible and intangible benefits, and you will have dollar values and relative values for the benefits. The approach to the evaluation will depend upon whether or not the intangible benefits are significant factors in the cost analysis. The word significant is very subjective, and each CBA team will have to decide what that means. If there is no realistic way to relate the value of the intangible benefits to the tangible ones, then they cannot be considered significant for the cost analysis.

If the intangible benefits are not considered to significant cost factors, they can be used as tie breakers if the evaluation of alternatives does not show that one alternative is a clear winner on the basis of net present value, benefit to cost ratio, or the incremental benefit to cost ratio. That process was described in Section 4.10, so a sample case is not included.

When intangible benefits are significant factors in the analysis, there are two options that may be exercised. If it is possible, the relative values may be converted to dollar values. This is a very difficult thing to do, and may be impossible to defend. There is no proven basis for assigning a dollar value to a benefit such as lower technical risk, and the amount of the dollar value could be used to influence the selection of the best alternative. Ultimately, the issue is whether or not is can be justified to the individual(s) that reviews and approves the CBA. The advantage is that you are working with all dollar values, and the evaluation process is simpler than the second option, which is converting dollar values to relative values.

The second option when the intangible benefits are significant factors in the analysis is to convert the dollar value of the tangible benefits to the same rating scale as the relative values of the intangible benefits. Exhibit 19, Mixed Benefit Values, shows a case where five of the seven benefits have been assigned dollar values, and two were assigned relative numeric values.

Exhibit 19, Mixed Benefit Values

Benefit	Reviewer 1 Score	Reviewer 2 Score	Reviewer 3 Score	Reviewer 4 Score	Reviewer Average Score
A	100,000.00	75,000.00	90,000.00	105,000.00	92,500.00
B	4.50	2.00	3.25	4.00	3.44
C	200,000.00	225,000.00	150,000.00	175,000.00	187,500.00
D	4.00	3.75	2.50	2.00	3.06
E	500,000.00	400,000.00	450,000.00	375,000.00	431,250.00
F	300,000.00	275,000.00	325,000.00	300,000.00	300,000.00
G	200,000.00	400,000.00	500,000.00	30,000.00	282,500.00

In this example, the dollar values can be converted to numerical scale values between 0 and 5 by dividing by $100,000. Exhibit 20, Converted Benefit Values, shows the ratings after they have all been converted to scaled values.

Exhibit 20, Converted Benefit Values

Benefit	Reviewer 1 Score	Reviewer 2 Score	Reviewer 3 Score	Reviewer 4 Score	Reviewer Average Score
A	1.00	0.75	0.90	1.05	0.93
B	4.50	2.00	3.25	4.00	3.44
C	2.00	2.25	1.50	1.75	1.88
D	4.00	3.75	2.50	2.00	3.06
E	5.00	4.00	4.50	3.75	4.31
F	3.00	2.75	3.25	3.00	3.00
G	2.00	4.00	5.00	3.00	3.50

Exhibit 21, Weighted Relative Benefits, shows the weighting of the scaled values for the benefits for two alternatives.

Exhibit 21, Weighted Relative Benefits

Benefit	Alternative 1 Raw Score	Alternative 2 Raw Score	Weighting Factor	Alternative 1 Weighted Score	Alternative 2 Weighted Score
A	0.93	2.25	10.00	9.25	22.50
B	3.44	3.75	9.00	30.94	33.75
C	1.88	2.25	9.00	16.88	20.25
D	3.06	3.80	8.00	24.50	30.40
E	4.31	3.10	6.00	25.88	18.60
F	3.00	4.60	5.00	15.00	23.00
G	3.50	4.70	5.00	17.50	23.50
TOTAL	20.11	24.45		139.94	172.00

At this point, the analysis can proceed using the evaluation techniques for the situation where the benefits are not assigned dollar values (4.10.2, Evaluate With Relative Benefits).

4.10.4 Flexibility

The different methods for evaluating alternatives provides a great deal of flexibility in selecting the best alternative; however, the evaluation technique must withstand the scrutiny of an investment review group that will ask hard questions about the entire analysis process. You may want to use two techniques to see if the same alternative is selected. If two different techniques select the same alternative, it should indicate that the analyses are valid and accurate. Another way to validate a cost-benefit analysis is through a sensitivity analysis, which is addressed in detail in the next section.

4.11 STEP 11 - PERFORM SENSITIVITY ANALYSIS

Sensitivity analysis tests the sensitivity of input parameters and the reliability of the results obtained from the benefit-cost analysis. Since the cost-benefit analysis is the key document in the investment review process, reviewers will want assurance that the analysis is valid. They are likely to ask questions about the accuracy of different parameters and cost estimates and their impact on the final recommendation. The sensitivity analysis should assure reviewers that the analysis provides a sound basis for making decisions regarding the proposed project. The sensitivity analysis process requires three steps: identification of input parameters with the greatest influence on the outcome, repetition of the cost analysis, and evaluation of the results.

4.11.1 Identify Input Parameters

The ground rules and assumptions documented earlier in the benefit-cost analysis are now used to identify the model inputs to be tested for sensitivity. Input parameters that are good candidate for testing are those that are both significant (large) cost factors and have a wide range of maximum and minimum estimated values. Some common parameters to be considered include the following:

- System Requirement Definition Costs
- System Development Costs
- System Operation Costs
- Transition Costs, Especially Software Conversion
- System Life Cycle
- Peak System Demands
- Dollar Values and Relative Values for Benefits

4.11.2 Repeat the Cost Analysis

The repetition of the cost analysis includes the following steps:

1. Choose one of the parameters selected for testing.
2. Determine the minimum and maximum values for that parameter.
3. Choose the minimum or maximum value as the new parameter value (the number selected should be the one that differs the most from the value used in the original analysis).
4. Repeat the benefit-cost analysis with the new parameter value[7].
5. Document the results.
6. Repeat the steps 1 through 5 until all important parameters have been tested.

After repeating the above process for several different parameters, you will have a set of outcomes that correspond to a given set of inputs. Some analysts may want to do a "worst case" scenario where several parameters are set to their worst possible values. Tabulation of the results will provide a summary of the different outcomes, allowing the results to be quickly evaluated, as shown below.

Exhibit 22, Sensitivity Analysis Summary

Parameter	*Parameter Value*	*Best Alternative*
Development Cost ($)	**1,500,000**	**A**
	2,000,000	**A**
	2,500,000	**B**
Transition Costs ($)	**100,000**	**A**
	200,000	**A**
System Life Cycle (Years)	**5**	**A**
	10	**B**
	15	**C**
Benefits ($)	**1,500,000**	**A**
	2,250,000	**A**
	3,000,000	**B**

4.11.3 Evaluate The Results

Evaluation is done by comparing the original set of inputs and the resulting outcome to the outcomes obtained by varying the input parameters. In the example above, the original values are the first value listed for each parameter. Sensitivity is measured by how much change in a parameter is required to change the alternative selected in the original analysis. Sensitivity is another very subjective word, so the following guidelines are provided:

- A parameter is not considered to be sensitive if it requires a decrease of 50% or an increase of 100% to cause a change in the selected alternative.
- A parameter is considered to be sensitive if a change between 10% and 50% causes a change in the selected alternative.

[7] It is assumed that a spreadsheet, such as Excel, Lotus or QuattroPro, was used for the original analysis. The analysis can be repeated with different inputs relatively quickly using any of the spreadsheets that are currently available.

- A parameter is considered to be very sensitive if a change of 10% or less causes a change in the selected alternative.

In the example shown above, the analysis would appear to be somewhat sensitive to the development costs, but not sensitive to the transition costs and benefits. The selection of three different alternatives based on three different system life cycles demonstrates that system life cycle is an important parameter, and illustrates that the guidelines above cannot be used as absolute criteria.

Sensitive parameters warrant further study. Assumptions, data sources, and analyses should be revisited to ensure that the best possible value is used for that parameter. If the analysis is found to be sensitive to several parameters, return to the beginning of the analysis and review all ground rules and assumptions. The final cost-benefit analysis report should include a sensitivity analysis that demonstrates that sensitive parameters have been carefully investigated and the best possible values have been used in the final analysis.

APPENDIX A - GLOSSARY OF TERMS

Note: most of the definitions are from OMB Circular A-94.

Benefit-Cost Analysis -- A systematic quantitative method of assessing the desirability of Government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects.

Capital Asset -- Tangible property, including durable goods, equipment, buildings, installations, and land.

Cost-Benefit Analysis -- An evaluation of the costs and benefits of alternative approaches to a proposed activity to determine the best alternative. (Definition created for this document)

Cost-Effectiveness Analysis -- A systematic quantitative method for comparing the costs of alternative means of achieving the same stream of benefits or a given objective.

Discount Rate -- The interest rate used in calculating the present value of expected yearly benefits and costs.

Discount Factor -- The factor that translates expected benefits or costs in any given future year into present value terms. The discount factor is equal to $1/(1 + i)t$ where i is the interest rate and t is the number of years from the date of initiation for the program or policy until the given future year.

Inflation -- The proportionate rate of change in the general price level, as opposed to the proportionate increase in a specific price. Inflation is usually measured by a broad-based price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index.

Information Technology -- Any equipment or interconnected system or subsystems of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception, of data or information.

Life Cycle Cost -- The overall estimated cost for a particular program alternative over the time period corresponding to the life of the program including direct and indirect initial costs plus any periodic or continuing costs of operation and maintenance.

Net Present Value -- The difference between the discounted present value of benefits and the discounted present value of costs.

Real or Constant Dollar Values -- Economic units measured in terms of constant purchasing power. A real value is not affected by general price inflation. Real values can be estimated by deflating nominal values with a general price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index.

Sunk Cost -- A cost incurred in the past that will not be affected by any present or future decision. Sunk costs should be ignored in determining whether a new investment is worthwhile.

APPENDIX B - BASELINE COST ELEMENT MATRIX

Baseline Cost Element Matrix*

	Supercomputing	*Mainframe*	*Desktop*	*Network*
Personnel (Civil Service, Contractor & Comm. Corps)	! Engineering ! Operations ! Problem Mgmt ! Config. Mgmt ! Maintenance ! User interface ! Administrative	! Engineering ! Operations ! Problem Mgmt ! Config. Mgmt ! Maintenance ! User Interface ! Administrative	! Engineering ! Operations ! Problem Mgmt ! Config. Mgmt ! Maintenance ! User Interface ! Administrative	! Engineering ! Operations ! Problem Mgmt ! Config. Mgmt ! Maintenance ! User Interface ! Administrative
Equipment	! Processor ! Console & Sys. ! Mgmt. Devices ! Disk Storage ! Tape Storage ! Interface Units	! Processor ! Console & Sys. ! Mgmt. Devices ! Disk Storage ! Tape Storage ! Interface Units	! PC ! Workstation	! Switches ! Routers ! Channel ! Extenders ! Multiplexors ! Specific Service
Software License & Purchase	! Operating System ! Application ! Data Base Management ! Monitoring Tools	! Operating System ! Application ! Data Base Management ! Monitoring Tools	! Server ! Client Application	! Monitoring Tools
Transmission				! Local Area ! Wide Area
Facility	! Floor space ! Standard Power ! Power Distribution ! Uninterruptable Power ! Heating & AC ! Liquid Cooling ! Custodial, Supplies	! Floor space ! Standard Power ! Power Distribution ! Uninterruptable Power ! Heating & AC ! Liquid Cooling ! Custodial, Supplies		! Floor space ! Standard Power ! Power Distribution ! Uninterruptable Power ! Heating & AC ! Custodial, Supplies

* Based on Benefit-Cost Study Performed for the Federal Aviation Administration

APPENDIX C -SPECIAL GUIDANCE FOR LEASE-PURCHASE ANALYSIS
Section 13, OMB Circular A-94

The special guidance in this section does not apply to the decision to acquire the use of an asset. In deciding that, the agency should conduct a benefit-cost analysis, if possible. Only after the decision to acquire the services of an asset has been made is there a need to analyze the decision whether to lease or purchase.

a. Coverage. The Circular applies only when both of the following tests of applicability are satisfied:

1. The lease-purchase analysis concerns a capital asset, (including durable goods, equipment, buildings, facilities, installations, or land) which:
   (a) Is leased to the Federal Government for a term of three or more years; or,
   (b) Is new, with an economic life of less than three years, and leased to the Federal Government for a term of 75 percent or more of the economic life of the asset; or,
   (c) Is built for the express purpose of being leased to the Federal Government; or,
   (d) Is leased to the Federal Government and clearly has no alternative commercial use (e.g., a special-purpose government installation).

2. The lease-purchase analysis concerns a capital asset or a group of related assets whose total fair market value exceeds $1 million.

b. Required Justification for Leases. All leases of capital assets must be justified as preferable to direct government purchase and ownership. This can be done in one of three ways:

1. By conducting a separate lease-purchase analysis. This is the only acceptable method for major acquisitions. A lease represents a major acquisition if:
   (a) The acquisition represents a separate line-item in the agency's budget;
   (b) The agency or OMB determines the acquisition is a major one; or
   (c) The total purchase price of the asset or group of assets to be leased would exceed $500 million.
2. By conducting periodic lease-purchase analyses of recurrent decisions to lease similar assets used for the same general purpose. Such analyses would apply to the entire class of assets. OMB approval should be sought in determining the scope of any such generic analysis.

3. By adopting a formal policy for smaller leases and submitting that policy to the OMB for approval. Following such a policy should generally result in the same lease-purchase decisions as would conducting separate lease-purchase analyses. Before adopting the policy, it should be demonstrated that:
   (a) The leases in question would generally result in substantial savings to the Government that could not be realized on a purchase;
   (b) The leases are so small or so short-term as to make separate lease-purchase analysis impractical; and
   (c) Leases of different types are scored consistently with the instructions in Appendices B and C of OMB Circular No. A-11.

c. Analytical Requirements and Definitions. Whenever a Federal agency needs to acquire the use of a capital asset, it should do so in the way that is least expensive for the Government as a whole.

1. Life-Cycle Cost. Lease-purchase analyses should compare the net discounted present value of the life-cycle cost of leasing with the full costs of buying or constructing an identical asset. The full costs of buying include the asset's purchase price plus the net discounted present value of any relevant ancillary services connected with the purchase. (Guidance on the discount rate to use for lease-purchase analysis is in Section 8.c.)

2. Economic Life. For purposes of lease-purchase analysis, the economic life of an asset is its remaining or productive lifetime. It begins when the asset is acquired and ends when the asset is retired from service. The economic life is frequently not the same as the useful life for tax purposes.

3. Purchase Price. The purchase price of the asset for purposes of lease-purchase analysis is its fair market value, defined as the price a willing buyer could reasonably expect to pay a willing seller in a competitive market to acquire the asset.
   (a) In the case of property that is already owned by the Federal Government or that has been donated or acquired by condemnation, an imputed purchase price should be estimated. (Guidance on making imputations is provided in Section 13.c.(6).)
   (b) If public land is used for the site of the asset, the imputed market value of the land should be added to the purchase price.
   (c) The asset's estimated residual value, as of the end of the period of analysis, should be subtracted from its purchase price. (Guidance on estimating residual value is provided in Section 13.c.(7).)

4. Taxes. In analyzing the cost of a lease, the normal payment of taxes on the lessor's income from the lease should not be subtracted from the lease costs since the normal payment of taxes will also be reflected in the purchase cost. The cost to the Treasury of special tax benefits, if any, associated with the lease should be added to the cost of the lease. Examples of such tax benefits might include highly accelerated depreciation allowances or tax-free financing.

5. Ancillary Services. If the terms of the lease include ancillary services provided by the lessor, the present value of the cost of obtaining these services separately should be added to the purchase price. Such costs may be excluded if they are estimated to be the same for both lease and purchase alternatives or too small to affect the comparison. Examples of ancillary services include:
   (a) All costs associated with acquiring the property and preparing it for use, including construction, installation, site, design, and management costs.
   (b) Repair and improvement costs (if included in lease payments).
   (c) Operation and maintenance costs (if included in lease payments).
   (d) Imputed property taxes (excluding foreign property taxes on overseas acquisitions except where actually paid). The imputed taxes approximate the costs of providing municipal services such as water, sewage, and police and fire protection. (See Section (6) below.)
   (e) Imputed insurance premiums. (See Section (6) below.)

6. Estimating Imputed Costs. Certain costs associated with the Federal purchase of an asset may not involve a direct monetary payment. Some of these imputed costs may be estimated as follows.
   (a) Purchase Price. An imputed purchase price for an asset that is already owned by the Federal Government or which has been acquired by donation or condemnation should be based on the fair market value of similar properties that have been traded on commercial markets in the same or similar localities. The same method should be followed in estimating the imputed value of any Federal land used as a site for the asset.
   (b) Property Taxes. Imputed property taxes may be estimated in two ways.
      (i) Determine the property tax rate and assessed (taxable) value for comparable property in the intended locality. If there is no basis on which to estimate future changes in tax rates or assessed values, the first- year tax rate and assessed value (inflation adjusted for each subsequent year) can be applied to all years. Multiply the assessed value by the tax rate to determine the annual imputation for property taxes.
      (ii) As an alternative to step (i) above, obtain an estimate of the current local effective property tax rate from the Building Owners and Managers Association's Regional Exchange Reports. Multiply the fair market value of the government-owned property (inflation adjusted for each year) by the effective tax rate.
   (c) Insurance Premiums. Determine local estimates of standard commercial coverage for similar property from the Building Owners and Managers Association's Regional Exchange Reports.

7. Residual Value. A property's residual value is an estimate of the price that the property could be sold for at the end of the period of the lease-purchase analysis, measured in discounted present value terms.
   (a) The recommended way to estimate residual value is to determine what similar, comparably aged property is currently selling for in commercial markets.
   (b) Alternatively, book estimates of the resale value of used property may be available from industry or government sources.
   (c) Assessed values of similar, comparably aged properties determined for property tax purposes may also be used.

8. Renewal Options. In determining the term of a lease, all renewal options shall be added to the initial lease period.

APPENDIX D - OMB A-11 COST CATEGORIES

Cost Category	Definition/Explanation	Object Class Codes
1. Equipment	Any equipment or interconnected system or subsystem of equipment used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, inter-change, transmission, or reception of data or information.	
A. Capital Purchases	Capital investments for equipment for data processing and telecommunications, such as super-computers, mainframes, mini-computers, microcomputers, analog and digital private branch exchanges (PBX), ancillary equipment, such as disk drives, tape drives, plotters, printers, storage and back-up devices cable-connected to computers, digital imaging equipment, optical storage and/or retrieval equipment, (e.g., optical character recognition devices, computer-generated microfilm and other data acquisition devices), punch card accounting equipment, and office automation equipment that was designed for use in conjunction with or controlled by a computer system; and telecommunications networks and related equipment, such as voice communications networks, data communications networks, local area networks, terminals, modems, data encryption devices, fiber optical and other communications networks, packet switching equipment, terrestrial carrier equipment (e.g., multipliers and concentrators), lightwave, microwave or satellite transmission and receiving equipment, telephonic (including cellular and other hand held devices) equipment, and facsimile equipment. Does not include furniture, typewriters, copiers, calculators, or microfilm/microfiche equipment.	**31.0**
B. Other Equipment Purchases/Leases	Non-capital purchases or leases for equipment as defined above.	**23.3 and 31.0**
2. Software	Any software, including firmware, specifically designed to make use of and extend the capabilities of Federal Information Processing (FIP) equipment identified in item 1 above.	
A. Capital Purchases	Software purchases (including one-time obligations for long-term licenses) or leases costing $25,000 or more for system programs (e.g., control and library programs, assemblers, compilers, interpreters, utility programs, sort-merge programs, and maintenance-diagnostic programs); application programs; and commercial-off-the-shelf (COTS) software (e.g., word processing, communications, graphics, file-management and database management system software). Software also includes independent subroutines, related groups of routines, sets or systems of programs; databases; and software documentation.	**31.0**
B. Other Software Purchases/Leases	Software purchases or leases costing less than $25,000.	**31.0**

3. Services	Any service, other than support services, performed or furnished by using the equipment or software identified in items 1 and 2 above. Services include teleprocessing, local batch processing, electronic mail, voice mail, centrex, cellular telephone, facsimile, and packet switching of data.	**23.1, 23.2, 23.3, and 25.2**
4. Support services	Any commercial services, including maintenance, used in support of equipment, software, or services identified in items 1, 2, and 3 above. Support services include source data entry, training, planning for the use and acquisition of information technology, studies (e.g., requirements analysis, analyses of alternatives, and conversion studies), facilities management of government-furnished information technology, custom software development, system analysis and design, and computer performance evaluation and capacity management.	**25.7 and 32.0**
5. Supplies	Any consumable item designed specifically for use with equipment, software, services, or support services identified in items 1, 2, 3, and 4, above.	**25.2, 25.3, and 26.0**
6. Personnel (compensation and benefits)	Includes the salary (compensation) and benefits for government personnel (both civilian and/or military) who perform information technology functions 51% or more of their time. Functions include but are not limited to policy, management, systems development, operations, telecommunications, computer security, contracting, and secretarial support. Personnel in user organizations who simply use information technology assets incidental to the performance of their primary functions are not to be included.	**11.1 through 12.2**
7. Other (DOD use only) **A. Capital purchases** **B. Other purchases**	Include items not otherwise reported in items 1 through 6 above. Items costing $25,000 or more. Items costing less than $25,000.	
8. Intra-governmental payments	Payments for all information technology services within agencies, between executive branch agencies (e.g., FTS 2000), judicial and legislative branches, and State and local governments.	**23.3, 25.3, and 41.0**
9. Intra-governmental collections	Collections for all information technology services within agencies, between executive branch agencies, judicial and legislative branches, and State and local governments.	

APPENDIX E - DISCOUNT FACTORS

Discount Factors for Discount Rate of 7 Percent

In the formulas below, I = interest rate (7%), and n = number of years, ^ indicates that the number following it is an exponent.

Year	Year-end Discount Factors 1/(1+I)^n	Mid-year Discount Factors 1/(1+I)^(n-.5)	Year-start Discount Factors 1/(1+I)^(n-1)
1	0.9346	0.9667	1.0000
2	0.8734	0.9035	0.9346
3	0.8163	0.8444	0.8734
4	0.7629	0.7891	0.8163
5	0.7130	0.7375	0.7629
6	0.6663	0.6893	0.7130
7	0.6227	0.6442	0.6663
8	0.5820	0.6020	0.6227
9	0.5439	0.5626	0.5820
10	0.5083	0.5258	0.5439
11	0.4751	0.4914	0.5083
12	0.4440	0.4593	0.4751
13	0.4150	0.4292	0.4440
14	0.3878	0.4012	0.4150
15	0.3624	0.3749	0.3878
16	0.3387	0.3504	0.3624
17	0.3166	0.3275	0.3387
18	0.2959	0.3060	0.3166
19	0.2765	0.2860	0.2959
20	0.2584	0.2673	0.2765
21	0.2415	0.2498	0.2584
22	0.2257	0.2335	0.2415
23	0.2109	0.2182	0.2257
24	0.1971	0.2039	0.2109
25	0.1842	0.1906	0.1971
26	0.1722	0.1781	0.1842
27	0.1609	0.1665	0.1722
28	0.1504	0.1556	0.1609
29	0.1406	0.1454	0.1504
30	0.1314	0.1359	0.1406

Note: Appendix C, **OMB Circular A-94**, has the latest Real Discount Rates that are to be used for discounting real (constant-dollar) flows, as is often required in cost-effectiveness analysis. The 1998 rates were 3.5% for 5 and 7 year periods, 3.6% for 10 years, and 3.8% for 30 years.